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WHAT DO THEY KNOW ABOUT HOW WE LEARN?

In the early 1980s, two physicists at Arizona State University wanted to know whether a typical introductory physics course, with its traditional emphasis on Newton's laws of motion, changed the way students thought about motion. As you read this account, you might substitute for the line "think about motion" any other phrase that fits your subject. Do the students in any class change the way they think?

To find out, Ibrahim Abou Halloun and David Hestenes devised and validated an examination to determine how students understand motion. They gave the test to people entering the classes of four different physics professors, all good teachers according to both colleagues and their students. On the front side, the results surprised no one. Most students entered the course with an elementary, intuitive theory about the physical world, what the physicists called "a cross between Aristotelian and 14th-century impetus ideas." In short, they did not think about motion the way Isaac Newton did, let alone like Richard Feynman. But that was before the students took introductory physics.

Did the course change student thinking? Not really. After the term was over, the two physicists gave their examination once more and discovered that the course had made comparatively small changes in the way students thought.[1] Even many "A" students continued to think like Aristotle rather than like Newton. They had memorized formulae and learned to plug the right numbers into them, but they did not change their basic conceptions. Instead, they had interpreted everything they heard about motion in terms

of the intuitive framework they had brought with them to the course.

Halloun and Hestenes wanted to probe this disturbing result a little further. They conducted individual interviews with some of the people who continued to reject Newton's perspectives to see if they could dissuade them from their misguided assumptions. During those interviews, they asked the students questions about some elementary motion problems, questions that required them to rely on their theories about motion to predict what would happen in a simple physics experiment. The students made their projections, and then the researchers performed the experiment in front of them so they could see whether they got it right. Obviously, those who relied on inadequate theories about motion had faulty predictions. At that point, the physicists asked the students to explain the discrepancy between their ideas and the experiment.

What they heard astonished them: many of the students still refused to give up their mistaken ideas about motion. Instead, they argued that the experiment they had just witnessed did not exactly apply to the law of motion in question; it was a special case, or it didn't quite fit the mistaken theory or law that they held as true. "As a rule," Halloun and Hestenes wrote, "students held firm to mistaken beliefs even when confronted with phenomena that contradicted those beliefs." If the researchers pointed out a contradiction or the students recognized one, "they tended at first not to question their own beliefs, but to argue that the observed instance was governed by some other law or principle and the principle they were using applied to a slightly different case."[2] The students performed all kinds of mental gymnastics to avoid confronting and revising the fundamental underlying principles that guided their understanding of the physical universe. Perhaps most disturbing, some of these students had received high grades in the class.

This story is part of a small but growing body of literature that

questions whether students always learn as much as we have traditionally thought they did. The scholarly work on this issue asks not if students can pass our examinations but whether their education has a sustained, substantial, and positive influence on the way they think, act, and feel. Researchers have found that even some "good" students may not progress as much intellectually as we once thought. They have discovered that some people make A's by learning to "plug and chug," memorizing formulae, sticking numbers in the right equation or the right vocabulary into a paper, but understanding little. When the class is over, they quickly forget much of what they have "learned."[3] Participants at a 1987 conference on science education, for example, saw this problem in math. "Those who successfully complete calculus," they concluded, "frequently fail to gain a conceptual understanding of the subject or an appreciation of its importance" because instructors rely on "'plug and chug' exercises that have little connection with the real world."[4] Even when learners have acquired some conceptual understanding of a discipline or field, they are often unable to link that knowledge to real-world situations or problem-solving contexts.

LEARNING FROM THE BEST

What do the best teachers know that helps them overcome—at least partially and sometimes fully—these problems?

We discovered that they know their disciplines well and are active and accomplished scholars, artists, or scientists—even if they do not always have long publication records. But that necessary knowledge alone can't account for their teaching success. If it did, then any expert in the field would become an outstanding educator, but that clearly doesn't happen. Nor is it the case that experts just need more time to become better teachers. We encountered many professors, all eminent scholars in their fields, who spent hours

crafting lectures that reflected the latest and most advanced scholarly and scientific knowledge only to produce students who understood little of that sophistication. One of those people, a medical school professor who was not part of the study, once told us with both pride and some measure of frustration that he didn't worry about whether students "got it" as long as every line of his lectures reflected the "highest standards of scientific quality and cutting-edge knowledge in the field."

What else do the best teachers know that might explain their successes in helping students learn deeply? We found two other kinds of knowledge that seem to be at play. First, they have an unusually keen sense of the histories of their disciplines, including the controversies that have swirled within them, and that understanding seems to help them reflect deeply on the nature of thinking within their fields. They can then use that ability to think about their own thinking—what we call "metacognition"—and their understanding of the discipline qua discipline to grasp how other people might learn. They know what has to come first, and they can distinguish between foundational concepts and elaborations or illustrations of those ideas. They realize where people are likely to face difficulties developing their own comprehension, and they can use that understanding to simplify and clarify complex topics for others, tell the right story, or raise a powerfully provocative question. There's a catch to all this, however. That kind of understanding is obviously rooted in each individual field of study and defies generalization.

Yet something else seems to be at work that transcends the various disciplines and therefore is more useful to our general study. To put it simply, the people we analyzed have generally cobbled together from their own experiences working with students conceptions of human learning that are remarkably similar to some ideas that have emerged in the research and theoretical literature on

cognition, motivation, and human development. Those ideas help them understand and cope with situations like the physics story and myriad other learning problems.

Here are the key concepts we found.

1. Knowledge Is Constructed, Not Received

Perhaps the best way to understand this notion is to contrast it with an older idea. According to the traditional view, memory is a great storage bin. We put knowledge in it and then later pick out what we need. Thus you often hear people say, "My students must learn the material before they can think about it," presumably meaning that they must store it somewhere for later use.

The best teachers don't think of memory that way, and neither do a lot of learning scientists. Instead, they say that we construct our sense of reality out of all the sensory input we receive, and that process begins in the crib. We see, hear, feel, smell, and taste, and we begin connecting all those sensations in our brains to build patterns of the way we think the world works. So our brains are both storage and processing units. At some point, we begin using those existing patterns to understand new sensory input. By the time we reach college, we have thousands of mental models, or schemas, that we use to try to understand the lectures we hear, the texts we read, and so forth.

For example, I have a mental model of something called a classroom. When I enter a room and receive some sensory input through the lens in my eyes, I understand the input in terms of that previously existing model, and I know I'm not in a train station. But this enormously useful ability can also present problems for learners. When we encounter new material, we try to comprehend it in terms of something we think we already know. We use our existing mental models to shape the sensory inputs we receive. That means that when we talk to students, our thoughts do not travel seamlessly from our brains to theirs. The students bring paradigms to the class

that shape how they construct meaning. Even if they know nothing about our subjects, they still use an existing mental model of something to build their knowledge of what we tell them, often leading to an understanding that is quite different from what we intend to convey. "The trouble with people," Josh Billings once remarked, "is not that they don't know but that they know so much that ain't so!"

I'm not just saying that students bring misconceptions to class, as a philosophy professor concluded a few years ago when he heard these ideas in a workshop. Actually, I'm arguing something much more fundamental: the teachers we encountered believe everybody constructs knowledge and that we all use existing constructions to understand any new sensory input. When these highly effective educators try to teach the basic facts in their disciplines, they want students to see a portion of reality the way the latest research and scholarship in the discipline has come to see it. They don't think of it as just getting students to "absorb some knowledge," as many other people put it. Because they believe that students must use their existing mental models to interpret what they encounter, they think about what they do as stimulating construction, not "transmitting knowledge." Furthermore, because they recognize that the higher-order concepts of their disciplines often run counter to the models of reality that everyday experience has encouraged most people to construct, they often want students to do something that human beings don't do very well: build new mental models of reality.

But that's the problem.

2. Mental Models Change Slowly

How can we stimulate students to build new models, to engage in what some call "deep" learning as opposed to "surface" learning in which they merely remember something long enough to pass the examination? Our subjects generally believe that to accomplish that feat, learners must (1) face a situation in which their mental model

will not work (that is, will not help them explain or do something); (2) care that it does not work strongly enough to stop and grapple with the issue at hand; and (3) be able to handle the emotional trauma that sometimes accompanies challenges to longstanding beliefs.

The teachers in our study often talked about "challenging students intellectually." That meant they wanted to create what some of the literature calls an "expectation failure," a situation in which existing mental models will lead to faulty expectations, causing their students to realize the problems they face in believing whatever they believe. Yet these highly effective teachers realized that human beings face too many expectation failures in life to care about all of them, so students may not engage in the deep thinking required to build completely new models. Furthermore, they understood that people have so many paradigms of reality that they may not know which of their schemas has led to the faulty predictions, so they may correct the wrong ones. That's partly where the physics students went wrong when they encountered experiments in which their conceptions of motion did not work. Finally, the best teachers understood that their students may find so much emotional comfort in some existing model of reality that they cling to it even in the face of repeated expectation failures.

Such ideas have important implications for the teachers. They conduct class and craft assignments in a way that allows students to try their own thinking, come up short, receive feedback, and try again. They give students a safe space in which to construct ideas, and they often spend a great deal of time creating a kind of scaffolding to help students engage in that construction (which is different from the popular notion of "covering" the material, but in ways that are sometimes difficult to grasp). Because they attempt to place students in situations in which some of their mental models will not work, they try to understand those models and the emotional baggage attached to them. They listen to student conceptions before

challenging them. Rather than telling students they are wrong and then providing the "correct" answers, they often ask questions to help students see their own mistakes.

Perhaps this general approach is most apparent in the way the teachers in the study approached a controversy that still rages in many disciplines, from the sciences to the humanities. On one side of that debate, teachers have argued that students cannot learn to think, to analyze, to synthesize, and to make judgments until they "know" the "basic facts" of the discipline. People in this school of thought have tended to emphasize the delivery of information to the exclusion of all other teaching activities. They seldom expect their students to reason (that will supposedly come after they have "learned the material"). On their examinations, these professors often test for recall, or simple recognition of information (on a multiple-choice examination, for example).

Teachers in our study come down on the other side of that controversy. They believe that students must learn the facts *while* learning to use them to make decisions about what they understand or what they should do. To them, "learning" makes little sense unless it has some sustained influence on the way the learner subsequently thinks, acts, or feels. So they teach the "facts" in a rich context of problems, issues, and questions.

Consider the approaches of two anatomy professors, one who has been enormously successful and was included in the study and the other, outside the study, who has, to put it gently, had difficulty fostering learning. The latter insisted that students must simply "learn the facts." There "isn't much to discuss," he told us. "The structure of the human body is well known by scientists, and students must simply absorb a lot of facts. There isn't any other way to teach except to stand in front of them and give them those facts. We can't discuss the way you might in a literature class." He talked about "transmitting" knowledge and insisted that the primary objective of the course was to "memorize large chunks of information."

The students must, he said, "commit it all to memory, store it away." His examinations reflected the same line of thinking. They required students largely to reproduce what the professor told them in class or to recognize correct answers. When we talked with some of his students, they often confessed that they had difficulty recalling information several months after the course was over. Meanwhile, the professor complained to us that students generally "didn't study hard enough" and that the "weak students" simply had difficulty "holding very much in their memory banks."

The other professor talked not about "absorbing information" but about "understanding" structures, how individual parts related to the whole, and—most important—the kinds of decisions that students would be able to make with the comprehension they "developed." She talked about helping students "build" their understanding and learn to "use the information" to solve problems, both scientific and medical. In class, she often did explain "how things work," trying to "simplify and clarify" basic concepts and ideas, but she also introduced problems, often clinical cases of "what could go wrong," and engaged the students in grappling with the issues those examples raised. Students encountered the information in the context of struggling, first with understanding and then with application of that comprehension. "I have to think," she told us, "about why anyone would want to remember particular pieces of information. What does this fact help you understand? What problems does it help you address?" She consciously thought about the "faulty paradigms" that the students brought with them to the class and crafted her explanations, discussions, and reading materials to challenge those notions. Her examinations followed suit. They asked students to struggle with clinical cases, to develop and defend their analyses, syntheses, and evaluations of those cases. They still had to recall a large body of information, but they also had to reason through problems.

3. Questions Are Crucial

In the learning literature and in the thinking of the best teachers, questions play an essential role in the process of learning and modifying mental models. Questions help us construct knowledge. They point to holes in our memory structures and are critical for indexing the information that we attain when we develop an answer for that inquiry. Some cognitive scientists think that questions are so important that we cannot learn until the right one has been asked: if memory does not ask the question, it will not know where to index the answer. The more questions we ask, the more ways we can index a thought in memory. Better indexing produces greater flexibility, easier recall, and richer understanding.

"When we can successfully stimulate our students to ask their own questions, we are laying the foundation for learning," one professor told us in a theme we heard repeatedly. "We define the questions that our course will help them to answer," another reminded us, "but we want them, along the way, to develop their own set of rich and important questions about our discipline and our subject matter."

4. Caring Is Crucial

People learn best when they ask an important question that they care about answering, or adopt a goal that they want to reach. If they don't care, they will not try to reconcile, explain, modify, or integrate new knowledge with old. They will not try to construct new mental models of reality. They may remember information for a short period (long enough to take the test), but only when their memory generates questions will it be prepared to change knowledge structures. Only then does it know where to place something. If we are not seeking an answer to anything, we pay little attention to random information.

These ideas about learning can help explain the story I told at

the beginning of this chapter. Those physics students who made A's yet failed to grasp anything about Newtonian concepts had not rebuilt their mental models about motion. They had merely learned to plug numbers into formulae without experiencing an expectation failure with the universes they imagined in their minds. They took all they heard from their professors and simply wrapped it around some pre-existing model of how motion works. Perhaps because they were focused on grades rather than on understanding the physical universe, they didn't care enough to grapple with their own ideas and build new paradigms of reality.

So what do the best teachers understand about motivation that enables them to help students care?

WHAT MOTIVATES? WHAT DISCOURAGES?

We found that highly successful teachers have developed a series of attitudes, conceptions, and practices that reflected well some key insights that have emerged from the scholarship on motivation.

For the last forty years or more, psychologists have studied what would happen if someone had a strong interest in doing something, and someone else offered them an "extrinsic" reward to bolster their "intrinsic" interest and then later withdrew that reinforcement. Would their fascination go up, stay the same, or go down? If, for example, students have a strong curiosity about what causes wars and we offer them extrinsic rewards in the form of grades to motivate their learning and then they later graduate, what will happen to their interests?

They actually go down. Research subjects tend to lose some or all of their intrinsic fascination once the extrinsic motivator is gone, at least under certain conditions. In one famous series of experiments, Edward L. Deci and his colleagues had two groups of students play with a block-construction puzzle called *Soma.* The subjects were brought to an examination room and asked to solve

the puzzle. Each time the examiner would leave the room for eight minutes. The psychologists wanted to know whether and how long the subjects would play with the *Soma* while they were gone (they observed the students from behind a one-way glass).

One group of subjects never got any rewards for solving the puzzle and never lost interest. A second group received money part of the time and lost interest when the compensation ended. Deci and others have performed scores of such experiments, trying several arrangements to see what would happen; they have consistently found that most extrinsic motivators damage intrinsic motivation. They have also found that if they use "verbal reinforcement and positive feedback"—in other words, encouragement or praise—they can stimulate interest, or at least keep it from evaporating.[5]

How do we account for the differences, and what do those differences tell us about motivating students to learn? Deci, Richard deCharms, and others have theorized that people lose much of their motivation if they think they are being manipulated by the external reward, if they lose what the psychologists have called their sense of the "locus of causality" of their behavior.[6] In other words, if people see certain conduct as a way to get a particular reward or avoid a punishment, then they will engage in those activities only when "they want the rewards and when they believe the rewards will be forthcoming from the behavior."[7] If they do not want that particular payoff, or if the possibility of reward is subsequently removed, they will lose interest in that activity. By contrast, as Deci put it, "verbal reinforcement, social approval, and so on . . . are less likely to be perceived by the person as controlling" behavior.[8] The key seems to be how the subject views the reward.

Investigators have also found that performance—not just motivation—can decrease when subjects believe that other people are trying to control them. If students study only because they want to get a good grade or be the best in the class, they do not achieve as much as they do when they learn because they are interested. They

will not solve problems as effectively, they will not analyze as well, they will not synthesize with the same mental skill, they will not reason as logically, nor will they ordinarily even take on the same kinds of challenges. They will usually opt for easier problems while those who work from intrinsic motivations will pick more ambitious tasks. They may become what some literature calls "strategic learners," focusing primarily on doing well in school, avoiding any challenges that will harm their academic performance and record, and often failing to develop deep understandings. Moreover, the effects seem to last. If students have been offered tangible extrinsic rewards to solve problems successfully and later lose those stimuli, they will continue to use less logical and efficient procedures than will students who never had the external incentive.[9]

Even certain kinds of verbal praise can be detrimental to learning. Young children who constantly hear "person" praise ("you're so smart to do this well") as opposed to "task" praise ("you did that well") are more likely to believe that intelligence is fixed rather than expandable with hard work. When they subsequently face setbacks after receiving person praise, their views of intelligence can cause them to develop a sense of helplessness ("I'm not as smart as I once thought I was"). When researchers asked these children to describe what made them feel smart, they talked about tasks they found easy, that required little effort, and that they could do before anyone else without making mistakes. In contrast, their peers who thought they got smarter by trying harder and learning new things said they felt intelligent when they didn't understand something, tried really hard, and then got it, or figured out something new. In other words, the children with the fixed view of intelligence and a sense of helplessness felt smart only when they avoided those activities most likely to help them learn—struggling, grappling, and making mistakes.[10]

These children are likely to have "performance goals." They want to achieve perfection or get the "right" answer to impress

other people because they want to appear to be one of the "smart people." They are afraid of making mistakes. They will often carefully calculate how much they need to achieve to win the proper praise and do no more than that, for fear that they might fail in the eyes of others. Some of these people do excel by some standards, but they still achieve primarily for the sake of that external recognition and fall short of where they might go. In contrast, students who believe that they can become more intelligent by learning (a "mastery orientation") often work essentially to increase their own competence (adopting "learning goals"), not to win rewards.[11] They are more likely to take risks in learning, to try harder tasks, and consequently learn more than children who are performance-oriented.[12]

What implications do these findings have for an academic culture that uses grades as a system of rewards and punishments? Is there a way to use grades that will not cause students to feel like they are being manipulated by the evaluation process? How can we best respond to students who develop a sense of helplessness? What do the best teachers do to keep students from becoming grade-grubbers and to stimulate an intrinsic interest in the subject?

In general, the people we investigated tried to avoid extrinsic motivators and to foster intrinsic ones, moving students toward learning goals and a mastery orientation. They gave students as much control over their own education as possible and displayed both a strong interest in their learning and a faith in their abilities. They offered nonjudgmental feedback on students' work, stressed opportunities to improve, constantly looked for ways to stimulate advancement, and avoided dividing their students into the sheep and the goats. Rather than pitting people against each other, they encouraged cooperation and collaboration. In general, they avoided grading on the curve, and instead gave everyone the opportunity to achieve the highest standard and grades.

Many of the best teachers do what Jeanette Norden does in her

medical school classes: grade students on the knowledge and abilities they have developed by the end of the class rather than on an average of accomplishments displayed throughout the term. For Norden and others, that means making each examination comprehensive, giving students multiple chances to demonstrate their comprehension. It also means constructing examinations with the greatest care to test the appropriate abilities comprehensively.

This practice of giving students many chances to demonstrate their learning parallels elements that Richard Light found in his study of the most intellectually satisfying classes at Harvard. Light and his colleagues interviewed thousands of current and former students, asking them about the qualities of the best courses they had taken at the university. In his 1990 initial report of findings, Light noticed that the "characteristics of highly respected courses" included "high demands" but "with plentiful opportunities to revise and improve their work before it receives a grade, thereby learning from their mistakes in the process."[13]

Most important, our outstanding teachers generally avoided using grades to persuade students to study. Instead, they invoked the subject, the questions it raises, and the promises it makes to any learner. In doing so, they displayed their own enthusiasm for the issues contained in the material. "I believe that if you've chosen your field properly," explained a professor of Slavic languages and literatures, "you've chosen it because it answers what I call the god inside of you—or if you like, the devil inside of you. If the students see you pursuing that, with all your heart, all your soul, and all your might, they'll respond."

This approach is apparent in a thousand little practices but probably most evident in the routine many outstanding teachers follow the first day of class. Rather than laying out a set of requirements for students, they usually talk about the promises of the course, about the kinds of questions the discipline will help students answer, or about the intellectual, emotional, or physical abili-

ties that it will help them develop. To be sure, they also explain what students will be doing to realize those promises—what many of us call the requirements—but they avoid the language of demands and use the vocabulary of promises instead. They invite, rather than command, and often display the attributes of someone inviting colleagues to dinner rather than the demeanor of a bailiff summoning someone to court.

The business of giving students some sense of control over their own education is no mean feat given that professors control both the curriculum and the questions that arise within each course. But our subjects managed to do it primarily by helping students see the connection between the questions of the course and the questions that students might bring to that course. Consider, for example, how we come to the questions and issues that currently drive our lives as scientists and scholars. Questions that interest us are usually important because of some previous inquiry, which, in turn, was significant because of some earlier question, which derived its own importance from some still earlier investigation, and so forth. We often live our scholarly lives focused on matters that lie several layers beneath the surface of topics that first intrigued us.

We saw teachers who dig back toward the surface, meet their students there, recapture the significance of those inquiries, and help people to understand why this question fascinates anyone. They do not simply call out from their position deep within the ground and ask students to join their subterranean mining expeditions. They help students to understand the connection between current topics and some larger and more fundamental inquiry, and in so doing find common ground in those "big questions" that first motivated their own efforts to learn. "How could you not be interested in organic chemistry?" David Tuleen asked. "It is the very basis of life itself."

A twentieth-century U.S. diplomatic history course, for example, usually spends some time on events immediately after World War I:

Woodrow Wilson's trip to Versailles, his attempt to win passage of the treaty and acceptance of U.S. entry into the League of Nations, his failure to take Republican leaders to France with him, his conflicts with Henry Cabot Lodge, and the divisions existing in the Senate at the time of the League vote, among others. It's a compelling story that Hollywood has used at least twice in popular movies. It even contains some elements of classic tragedy—Wilson orders supporters to vote against the treaty rather than accept a compromise. Yet students' interests in these topics always seem to hinge on whether they become intrigued with the personal story of Woodrow Wilson. If they do, bingo, you have them. If not, you lose them. Without that interest, some students have no concern for any of the scholarship surrounding this history. Who cares? they say.

Who does care, and why? Why do historians study these events? Not simply because they happened—many events happen that never attract the attention of scholars. If you trace the original scholarly interest in Wilson's trip to Paris (at least the interest that first appeared during World War II) you will find it emerged from a simple, yet important, series of higher questions: Could Wilson, or any other powerful individual, have prevented World War II with a different course of action in 1919 and 1920? Can human beings avoid wars? Furthermore, behind these questions lies an even more fundamental inquiry: Can people control their own destiny, or does some kind of determinism, economic or otherwise, sweep us along, making us hapless observers and chroniclers of our own fate and the antics of even a powerful individual such as Woodrow Wilson insignificant? These are big questions that intrigue and provoke virtually all students. It was this level of question that we often saw in the classes we studied, and it was an appeal to this kind of inquiry rather than to extrinsic motivators that captivated students.

The most effective teachers help students keep the larger questions of the course constantly at the forefront. Donald Saari, a mathematician from the University of California, invokes the prin-

ciple of what he calls "WGAD"—"Who gives a damn?" At the beginning of his courses, he tells his students that they are free to ask him this question on any day during the course, at any moment in class. He will stop and explain to his students why the material under consideration at that moment—however abstruse and minuscule a piece of the big picture it may be—is important, and how it relates to the larger questions and issues of the course.

Nancy MacLean, Charles Deering McCormick Professor of Teaching Excellence and Professor of History at Northwestern, offered these details: "On the first day of all my courses . . . I devote some time to the promised 'payoff,' connecting course themes or required skills to issues or interest likely to be on their minds. Some people might find this crude; I don't. Or rather, I don't care if it is: we're all too busy these days to show interest in something if we can't see why it might matter." As an example of how she does this, she mentioned a woman's history course she recently taught, during which her students informed her about a book called *The Rules: Time-Tested Secrets for Capturing the Hearts of Mr. Right.* Surprised at the number of students familiar with this text—an informal poll showed 85 percent—she read it, inserted sections from it into the syllabus, and allowed students an option to write a paper about it, one that would "provide a historical analysis of this document, drawing on as many course materials as possible, that situated and made sense of it in historical context." MacLean's willingness to bend the syllabus to accommodate this text speaks volumes about her intuitive understanding of motivation: she helped students re-see a familiar object in light of the analytic and historical tools with which her course had equipped them. She built a solid connection between her questions and her students' lives and interests.

The people we explored know the value that intellectual challenges—even inducing puzzlement and confusion—can play in stimulating interest in the questions of their courses. Several of them talked about finding the novel, the incongruous, and the

paradoxical. With carefully chosen analogies they make even the familiar seem strange and intriguing and the strange appear familiar. We found people who constantly sprinkle their classes with personal anecdotes and even emotional stories to illustrate otherwise purely intellectual topics and procedures. Many of them spoke about beginning with what seemed most familiar and fascinating to students and then weaving the new and different into the fabric of the course. One professor explained it this way: "It's sort of Socratic . . . You begin with a puzzle—you get somebody puzzled, and tied in knots, and mixed up." Those puzzles and knots generate questions for students, he went on to say, and then you begin to help them untie the knots.

In the broad literature on human motivation, there are frequent discussions of three factors that can influence different people in varied ways. Some people respond primarily to the challenge of mastering something, getting inside a subject and trying to understand it in all its complexity. Such people are considered deep learners. Others react well to competition, to the quest for the gold and the chance to do better than anyone else. While that can be a strong motivation for some, it can sometimes hinder learning. In the classroom, such individuals frequently become strategic learners, interested in making the high grades but seldom willing to grapple deeply enough to change their own perceptions. They learn for the test and then quickly expunge the material to make room for something else. "They are," Craig Nelson, a biology professor from Indiana, noted, "bulimic learners." Finally, we encounter people who seek primarily to avoid failure, what the literature calls "performance-avoiders." In the classroom, they often become surface learners, never willing to invest enough of themselves to probe a topic deeply because they fear failure, so they stick with trying to cope, to survive. They often resort to memorizing and trying simply to reproduce what they hear.

In interview after interview, we found professors who had a

strong sense of these categories of learners and a recognition that, if they tailored their appeals to individuals, they could influence how their students approached learning. They realized that human beings can and do change, and that the nature of their instruction can have an enormous influence on that process. "Performance avoiders" suffered from lack of self-confidence, so motivation to learn might come from a stronger belief that they can learn. The best teachers carefully constructed learning tasks and objectives to build confidence and to encourage, yet to give students strong challenges and a sense of sufficient accomplishment. They recognized also that the culture of some classrooms fosters bulimic learners, encouraging students to stress the regurgitation of facts and the subsequent purging.

"Schooling," one professor told us, "encourages many bright students to think of the enterprise as a competition to be won." Robert de Beaugrande said it just recently: "'Bulimic education' force-feeds the learner with a feast of 'facts' which are to be memorised and used for certain narrowly defined tasks, each leading to a single 'right answer' already decided by teacher or textbook. After this use, the facts are 'purged' to make room for the next feeding. 'Bulimic education' thus enforces an intensely local or short-range focus, irrespective of any long-range benefits that might arise from the succession of feed-purge cycles."[14]

To avoid such cycles, the teachers we observed usually abstain from appeals to competition. They stress the beauty, utility, or intrigue of the questions they try to answer with their students, and they pursue answers to questions rather than simply the "learning of information." They make promises to their students and try to help each one achieve as much as possible. Most important, they expect more than bulimic learning, crafting and outlining for their students fascinating notions about what it means to develop as intelligent and educated people. They bring to the table challenging objectives, but they also listen to their learners, to their ambitions,

and try to help them understand those aspirations in more sophisticated and satisfying ways. "I often have students," one professor told us, "who do not yet realize the potential they have for learning and the unique contributions they can make." In Chapter 4, we will explore more fully how highly effective professors expect more and inspire their students to achieve it.

TAKING A DEVELOPMENTAL VIEW OF LEARNING

Finally, our subjects realized that learning doesn't just affect what you know; it can transform how you understand the nature of knowing. Many of the teachers were aware of the work that William Perry and a group of psychologists at Wellesley College have done to understand the intellectual development of undergraduates. Both Perry and Blythe McVicker Clinchy and her colleagues have suggested four broad categories through which students can eventually travel, each one with its concept of what it means to learn. At the most elementary level, students think that learning is simply a matter of checking with the experts, getting the "right answers," then memorizing them.[15] Clinchy called these people "received knowers." "Truth, for the received knower," she argued, is external. "She can ingest it, but she cannot evaluate it or create it for herself. The received knowers are the students who sit there, pencils poised, ready to write down every word the teacher says."[16] They expect education to operate on what Paulo Freire has dubbed the "banking model," in which teachers deposit the correct answers into students' heads.

Eventually, many students find out that experts disagree. As a result, they come to believe—in the second developmental stage—that all knowledge is a matter of opinion. These "subjective knowers" use feelings to make judgments: To them, "an idea is right if it feels right," as Clinchy puts it.[17] It is all a matter of opinion. If

they receive low grades, students at this level will often say of the teacher, "she didn't like my opinion."

A few students eventually become "procedural knowers": they learn to "play the game" of the discipline. They recognize that it has criteria for making judgments and they learn how to use those standards in writing their papers. We usually recognize them as our sharpest students. Such "knowing" does not, however, influence how they think outside of class. They simply give the teacher what she wants without much sustained or substantial influence on the way they think, act, or feel.

Only at the highest level (what Perry calls "Commitment") do students become independent, critical, and creative thinkers, valuing the ideas and ways of thinking to which they are exposed and consciously and consistently trying to use them. They become aware of their own thinking and learn to correct it as they go. Clinchy and her colleagues found two types of knowers at the highest levels: "separate knowers" like to detach themselves from an idea, remaining objective, even skeptical, and always willing to argue about it. In contrast, "connected knowers" look at the merits of other people's ideas instead of trying to shoot them down. They are not "dispassionate, unbiased observers," the Wellesley study concluded. "They deliberately bias themselves in favor of the thing they are examining."[18]

According to this scheme, people don't just march upward; they move back and forth between levels and can operate on more than one developmental stage at a time. In their major they might rise to the level of procedural knowing; in other fields, they might remain received or subjective knowers. We might hear them demand "right answers" they can memorize, or watch them fail to make the distinctions our disciplines encourage and, therefore, think that all views are equally valid.

The best teachers talked about stimulating an "incremental

series" of changes in people's view of knowledge, and the need to adopt different approaches for various levels of learners. For received knowers, who often have trouble identifying relevant facts, they would encourage precise thinking (What are the key facts? What are the key definitions?). They confronted subjective knowing with the challenges of evidence and reason (How do we know this? Why do we accept or believe this idea?). For everyone, they taught the uncertainty of knowledge (What did scholars believe about this subject ten years ago? What are the questions we still need to answer?). For those students who have begun to master procedural knowing and are flirting with commitments, they would ask about their values and about the implications of their conclusions. But rather than rationing out such experiences in some planned lockstep, they tended to give all students all these experiences and challenges repeatedly, as if to recognize that while the process of maturing intellectually may involve incremental challenges, it is seldom linear. People develop in fits and starts and benefit from repeated challenges from a variety of levels. "Not every student benefits from the same set of experiences at the same time," concluded one professor, "and that's the reason I try to give different people different kinds of challenges. Students operate on different levels and will not all catch on at the same time."

Some instructors have deliberately introduced students to the concepts of connected and separate knowing and have acknowledged the value of both tendencies. They often tell their students that though they usually want them to be separate knowers, to be skeptical and adversarial, sometimes they want them to be connected knowers, to suspend judgment until they have a better understanding of something. Clinchy argues that while both men and women can be predominantly separate or connected knowers, more women than men prefer the latter. Thus she concluded that "educational practices based on an adversarial model may be more

appropriate—or at least less stressful—for men than for women."[19] Yet among the professors in our study who were aware of these concepts, there was no clear pattern of either acceptance or rejection.

Even so, the best teachers exhibited a special sensitivity both to the problems that all students face in navigating these sometimes treacherous and often disturbing waters and to the special problems that some encounter. They didn't say simply "if some students can learn" in a certain way, "all students can do so." Rather, they accommodated the diversity they found, and even responded with sympathy and understanding to the emotional transitions people undergo when they encounter new ideas and material. They recognized that students may experience feelings of resentment and hostility when they discover that truth does not reside in the heads of their teachers. They were familiar with the stages of intellectual transition and so understood when students responded strongly and viscerally to ideas and questions professors take for granted.

The most successful teachers expect the highest levels of development from their students. They reject the view of teaching as nothing more than delivering correct answers to students and learning as simply remembering those deliveries. They expect their students to rise above the category of received knowers, something they reflect in the way they teach and assess their students. They even draw clear distinctions between those students who "do the discipline" for the sake of the class (the procedural knowers) and those students whose ways of thinking and drawing conclusions are permanently transformed.

Whereas some professors might see their job as teaching the facts, concepts, and procedures of their subject, the teachers we studied emphasized the pursuit of answers to important questions and often encouraged students to use the methodologies, assumptions, and concepts from a variety of fields to solve complex problems. They often incorporated literature from other fields into their

teaching and emphasized what it means to get an education. They spoke about the value of an integrated education rather than one fragmented between individual courses.

That is not to say that they did not teach their own disciplines. They did, but in the context of focusing on the intellectual, and often ethical, emotional, and artistic, development of their students. Indeed, rather than thinking just in terms of teaching history, biology, chemistry, or other topics, they talked about teaching *students* to understand, apply, analyze, synthesize, and evaluate evidence and conclusions. They stressed the ability to make judgments, to weigh evidence, and to think about one's own thinking. Many of them spoke about the importance of developing intellectual habits, of asking the right questions, of examining one's values, of aesthetic tastes, of recognizing moral decision, and of looking at the world in a different way. "I want my students to understand what we think we know in this field," one scientist explained, "but I also hope they will understand how we reached those conclusions and how those findings are subject to ongoing inquiry. I want them to ask, 'why do we think this is the case, what assumptions have we made, what evidence do we have, how have we reasoned to get to this point?' But I also want them to ask themselves about the implications our conclusions might have." Rather than emphasizing how well students could perform on examinations, they often talked about ways to transform conceptual understanding, foster advanced reasoning skills, and the ability to examine one's own thinking critically.

IMPLICATIONS FOR TEACHING

The major ideas that animate the best teachers stem from a very basic observation: Human beings are curious animals. People learn naturally while trying to solve problems that concern them. They develop an intrinsic interest that guides their quest for knowledge,

and an intrinsic interest—and here's the rub—that can diminish in the face of extrinsic rewards and punishments that appear to manipulate their focus. People are most likely to enjoy their education if they believe they are in charge of the decision to learn.

The best college and university teachers create what we might call a natural critical learning environment in which they embed the skills and information they wish to teach in assignments (questions and tasks) students will find fascinating—authentic tasks that will arouse curiosity, challenging students to rethink their assumptions and examine their mental models of reality. They create a safe environment in which students can try, come up short, receive feedback, and try again. Students understand and remember what they have learned because they master and use the reasoning abilities necessary to integrate it with larger concepts. They become aware of the implications and applications of the ideas and information. They recognize the importance of measuring their own work intellectually as they do it, and in the process they routinely apply the intellectual standards of a variety of disciplines. They cease to be Aristotelian physicists and become Newtonian ones because they've come to care enough to question themselves.

Achievement?" *Teaching of Psychology* 5 (1978): 86–88; P. C. Abrami, S. d'Apollonia, and P. A. Cohen, "Validity of Student Ratings of Instruction: What We Know and What We Do Not," *Journal of Educational Psychology* 82 (1990): 219–231; K. A. Feldman, "Instructional Effectiveness of College Teachers as Judged by Teachers Themselves, Current and Former Students, Colleagues, Administrators, and External (Neutral) Observers," *Research in Higher Education* 30 (1989): 137–194; K. A. Feldman, "The Association between Student Ratings of Specific Instructional Dimensions and Student Achievement: Refining and Extending the Synthesis of Data from Multisection Validity Studies," *Research in Higher Education* 30 (1989): 583–645.

7. Kenton Machina, "Evaluating Student Evaluations," *Academe* 73 (1987): 19–22.

8. Herbert W. Marsh, "Experimental Manipulations of University Student Motivation and Effects on Examination Performance," *British Journal of Educational Psychology* 54 (1984): 206–213.

9. Nalini Ambady and Robert Rosenthal, "Half a Minute: Predicting Teacher Evaluations from Thin Slices of Nonverbal Behavior and Physical Attractiveness," *Journal of Personality and Social Psychology* 64 (1993): 431–441.

10. We believe these conclusions transcend much of the recent debate over traditional and innovative approaches to teaching, about passive or active learning, or about a "sage on the stage" versus a "guide by the side." They help explain why some professors stimulate learning using what others would regard as outmoded pedagogies while others fail miserably with the latest rage, and still others do the opposite. They speak to a higher set of considerations that ask not whether one has used the latest technologies and methodologies but about the kind of sustained and substantial influence the teaching has on the way students think, act, or feel.

11. For an introduction to some of this learning research, see John D. Bransford, Ann L. Brown, and Rodney R. Cocking, eds., *How People Learn: Brain, Mind, Experience and School* (Washington, D.C.: National Academy Press, 1999). See also notes to Chapter 2.

2. WHAT DO THEY KNOW ABOUT HOW WE LEARN?

1. Ibrahim Abou Halloun and David Hestenes, "The Initial Knowledge State of College Physics," *American Journal of Physics* 53 (1985): 1043–1055. See also Ibrahim Abou Halloun and David Hestenes, "Common

Sense Concepts about Motion," *American Journal of Physics* 53 (1985): 1056–1065.

2. Halloun and Hestenes, "Common Sense Concepts about Motion," quotation from p. 1059.

3. For further examples and discussions of this phenomenon in physics, see Jose P. Mestre, Robert Dufresne, William Gerace, Pamela Hardiman, and Jerold Touger, "Promoting Skilled Problem Solving Behavior among Beginning Physics Students," *Journal of Research in Science Teaching* 30 (1993): 303–317; Lilian C. McDermott, "How We Teach and How Students Learn," in Harold I. Modell and Joel A. Michael, eds., *Promoting Active Learning in the Life Science Classroom* (New York: The New York Academy of Sciences, 1993), pp. 9–19; and Sheila Tobias, *Revitalizing Undergraduate Science: Why Some Things Work and Most Don't* (Tucson: Research Corporation, 1992).

4. Kim A. McDonald, "Science and Mathematics Leaders Call for Radical Reform in Calculus Teaching." *Chronicle of Higher Education,* November 4, 1987, p. 1.

5. Edward L. Deci, "Effects of Externally Mediated Rewards on Intrinsic Motivation," *Journal of Personality and Social Psychology* 18 (1970): 105–115.

6. See Richard deCharms and Dennis J. Shea, *Enhancing Motivation: A Change in the Classroom* (New York: Irvington Publishers, 1976).

7. Edward L. Deci and Joseph Porac, "Cognitive Evaluation Theory and the Study of Human Motivation," in Mark R. Lepper and David Greene, eds., *The Hidden Costs of Reward: New Perspectives on the Psychology of Human Motivation* (Hillsdale, N.J.: Lawrence Erlbaum, 1978), pp. 149–176; quotation from p. 149.

8. Deci, "Effects of Externally Mediated Rewards on Intrinsic Motivation"; quotation from p. 107.

9. See J. Condry and J. Chambers, "Intrinsic Motivation and the Process of Learning," in *The Hidden Costs of Reward,* pp. 61–84; and T. S. Pittman, J. Emery, and A. K. Boggiano, "Intrinsic and Extrinsic Motivational Orientations: Reward-Induced Change in Preference for Complexity," *Journal of Personality and Social Psychology* 42 (1982): 789–797.

10. Melissa Kamins and Carol Dweck, "Person versus Process Praise and Criticism: Implications for Contingent Self-Worth and Coping," *Developmental Psychology* 35 (1999): 835–847.

11. See, for example, Carol S. Dweck, "Motivational Processes Affecting

Learning," *American Psychologist* 41 (1986): 1040–1048; and Carol W. Dweck and E. L. Leggett, "A Social-Cognitive Approach to Motivation and Personality," *Psychological Review* 95 (1988): 256–273.

12. In the 1980s, Susan Bobbitt Nolen studied children doing expository reading and noticed that if they had as their chief goal learning for "its own sake" (what she called "task orientation"), they were likely to use and value deep processing strategies in that reading. If the learners wanted primarily to do better than anyone else in the class (in her terms, "ego orientation"), they often used less sophisticated strategies, tending to engage in a superficial reading. See Susan Bobbitt Nolen, "The Influence of Task Involvement on the Use of Learning Strategies" (paper delivered at the Annual Meeting of the American Educational Research Association, Washington, D.C., April 20–24, 1987); Susan Bobbitt Nolen and Thomas M. Haladyna, "Personal and Environmental Influences on Students' Beliefs about Effective Study Strategies," *Contemporary Educational-Psychology* 15 (1990): 116–130.

13. Richard Light, *The Harvard Assessment Seminars* (Cambridge, Mass.: Harvard University, Graduate School of Education and Kennedy School of Government, 1990), pp. 8–9.

14. Robert de Beaugrande, "Knowledge and Discourse in Geometry: Intuition, Experience, Logic," *Zeitschrift für Phonetik, Sprachwissenschaft und Kommunikationsforschung* 6 (1991): 771–827; and *Journal of the International Institute for Terminology Research* 3/2 (1992): 29–125; quotation from the on-line version at *http://beaugrande.bizland.com/Geometry.htm.*

15. See William G. Perry, Jr., *Forms of Intellectual and Ethical Development in the College Years: A Scheme* (New York: Holt, Rinehart and Winston, 1970); William G. Perry, Jr., "Cognitive and Ethical Growth: The Making of Meaning," in Arthur W. Chickering, ed., *The Modern American College* (San Francisco: Jossey-Bass Publishers, 1990), pp. 76–116; Mary Field Belenky, Blythe McVicker Clinchy, Nancy Rule Goldberger, and Jill Mattuck Tarule, *Women's Ways of Knowing: The Development of Self, Voice, and Mind* (New York: Basic Books, 1986).

16. Blythe McVicker Clinchy, "Issues of Gender in Teaching and Learning," *Journal of Excellence in College Teaching* 1 (1990): 52–67; quotation from pp. 58–59.

17. Ibid., p. 59.

18. Ibid., p. 63.

19. Ibid., p. 65.